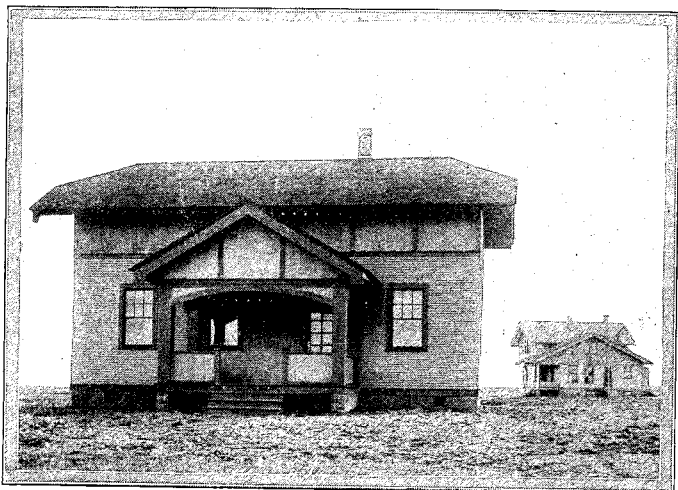


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THE UNIVERSITY OF WISCONSIN  
AGRICULTURAL EXPERIMENT STATION



NEW BUILDINGS AT ASHLAND BRANCH STATION

In one year this area of "cut over" land has been subdued and equipped for experimental work.

REPORT OF THE DIRECTOR  
1911-1912

BY

H. L. RUSSELL

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MADISON, WISCONSIN

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## REPORT OF THE DIRECTOR

1911—1912

H. L. RUSSELL

Twenty-five years ago, the Federal Congress passed the Hatch Act, introduced by Representative Hatch of Missouri, founding the system of agricultural experiment stations. These institutions were for the "purpose of acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science."

The beneficial results arising from this act have become better known as time has gone on. Twenty-five years ago, the practical farmer was very skeptical as to what science could do to aid him in his work. The early station leaders had an untried field before them, and a critical public with which to deal. With all of the apathy and opposition that obtained among the very class which this work was designed to help, the wonder is that Congress had the foresight to enact into law a measure of this character.

The original Hatch Act, appropriating to each state \$15,000 annually, was supplemented in 1906 by the Adams Act\* which added ultimately another \$15,000, making the federal grant to each state \$30,000 in all. The expectation was that as needs required this nucleus would be added to by the state itself. In this state, as in many others, this moral obligation has been met in a generous way.

Experimental work in this period of twenty-five years has undergone much transformation. The simple, evident problems

\*Hon. H. C. Adams, Member of Congress from this state and district, was the author of this supplementary Act.

that were comparatively easy of solution have now in large measure been solved. The problems of the future are necessarily more fundamental and oftentimes may not seem to have any direct practical bearing, but no one can foretell what highly beneficial results may be developed from the most profound researches. The American experiment station movement has set a standard that has served more or less as a model throughout the world. To-day, the interest in the work of these organizations is widespread, and by no means confined to the farmers themselves. The press and the general public now show a keen appreciation of things agricultural—a radical change from the apathy and even opposition of the earlier days.

The successful and efficient experiment station cannot remain content with mere investigation in the laboratory. The principles worked out here in detail must be tried out in the crucible of field experience to make sure that wrong conclusions are not put forth on the basis of inadequate data. The results of the laboratory must be extended to the farmers of the state.

### RESEARCH WORK OF THE EXPERIMENT STATION

The synopsis here presented records the more prominent lines of investigation that have been in progress during the fiscal year ending June 30, 1912. The completed results are published in bulletins from time to time, but these form at any time only a fraction of the entire group of problems that are under investigation. There is always much work that is only partially completed, but not infrequently, tentative conclusions concerning these questions can be presented that may be of real value to the public. The summary here recorded may therefore be considered in the light of a progress report of the activities of the past year.

#### PEA BLIGHT

One of the growing industries in the state is the pea canning business. The soil and climatic conditions in the shore regions of our great lakes, as well as some of the centrally located counties of the state, seem to be preeminently well suited to pea culture. Forty-five canning companies are reported this

year as growing 35,000 acres, while approximately 15,000 acres more are devoted to seed production.

Within recent years trouble has, however, developed in certain sections of the state, and the profitableness of the business has been in some cases seriously impaired. A year ago the ravages due to a disease known as pea blight were so severe in some sections as to cause almost total loss. This year 12 companies that were in operation in 1909 are out of business and others have been forced to turn from peas to vegetables.

Realizing the menace to their industry, the Pea Cannery Association last year importuned the Station for aid, but as funds had already been allotted, it was impossible to provide for this

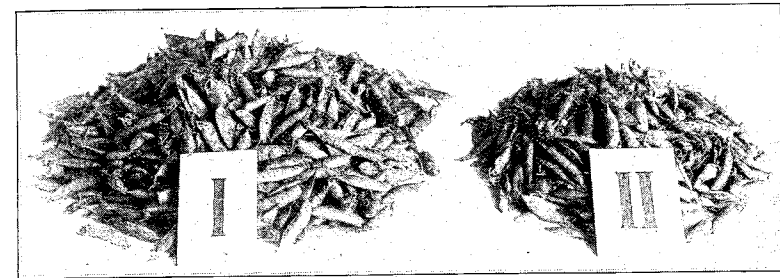


FIGURE 1. PEA BLIGHT CAN BE CONTROLLED BY SCIENTIFIC METHODS  
Spraying with Bordeaux mixture helps to control this fungus disease, in this trial more than doubling the yield of peas.

work. The Cannery Association thereupon subscribed a fund sufficient to permit research work to be undertaken, and Prof. L. R. Jones and Mr. R. E. Vaughan have been studying the problem, Mr. Vaughan's expenses being paid from this fund.

Several parasitic fungi have been investigated and the life history of two types sufficiently studied to make possible the trial of a rational system of prevention. The custom of growing the crop on the same areas without rotation (which practice has been generally followed where the canning company owns the land) affords most excellent conditions for the development of the disease, as the winter spores of the fungus mature on the pea stubble, and so infect the young plantlets as the seed germinates the next spring. One of the fungi lives over in the seed itself, and hence can be successfully prevented only by the use of healthy seed.

Field experiments were conducted in which pea straw as well as pea silage were plowed under. These showed a marked

increase in amount of diseased tissue, and a reduced yield of pods, in comparison with check plots. Spraying with Bordeaux mixture helps to control the disease. The results of the year already point out quite clearly the course which the growers will have to follow in order to hold these diseases in check.

#### CABBAGE DISEASES

Many of the cabbage growers in Racine and Kenosha counties have been driven out of business, so far as cabbage culture is concerned, through the ravages of certain fungus diseases affecting this plant. Prof. L. R. Jones, continuing his studies on these different diseases, has found that various commercial fertilizers, as well as soil disinfectants, are wholly useless as preventive agents for the control of this disease in infected soil. For several seasons he has turned his attention chiefly toward the breeding of resistant strains and this year is able to report most substantial progress in this direction. In fields planted with commercial varieties in 1910, where the disease caused almost an entire loss, the few naturally resistant heads were selected, and seed raised therefrom in 1911. While commercial seed planted on infected fields gave this year only 21% of living plants, the cabbage grown from the "resistant" seed developed 86% live plants, over half of which formed heads. Seed produced from the best head gave 93% of properly matured heads. Though the disease was not so destructive this year as it was in 1911, these results show the influence of careful selection and indicate clearly the great possibilities that lie in the use of home grown seed of disease resistant strains adapted to local conditions.

#### TOBACCO DISEASES

Continuing his study of tobacco diseases, Mr. Johnson of the Horticultural department has found that the strength of formalin solution ordinarily recommended as a soil drench to prevent damping off in the seed bed, only checks the development of the damping off fungi for a short time. However, when a stronger solution, one part formalin to 50 parts of water, is used, the fungi are killed. Steam sterilization has proven very satisfactory, not only preventing damping off, but also killing weeds and greatly increasing the rate of growth and the gen-

eral vigor of the plants, as is shown in Figure 3. A root rot of tobacco due to the fungus, *Thielavia basicola*, which is a serious disease in the eastern states, during the past year caused

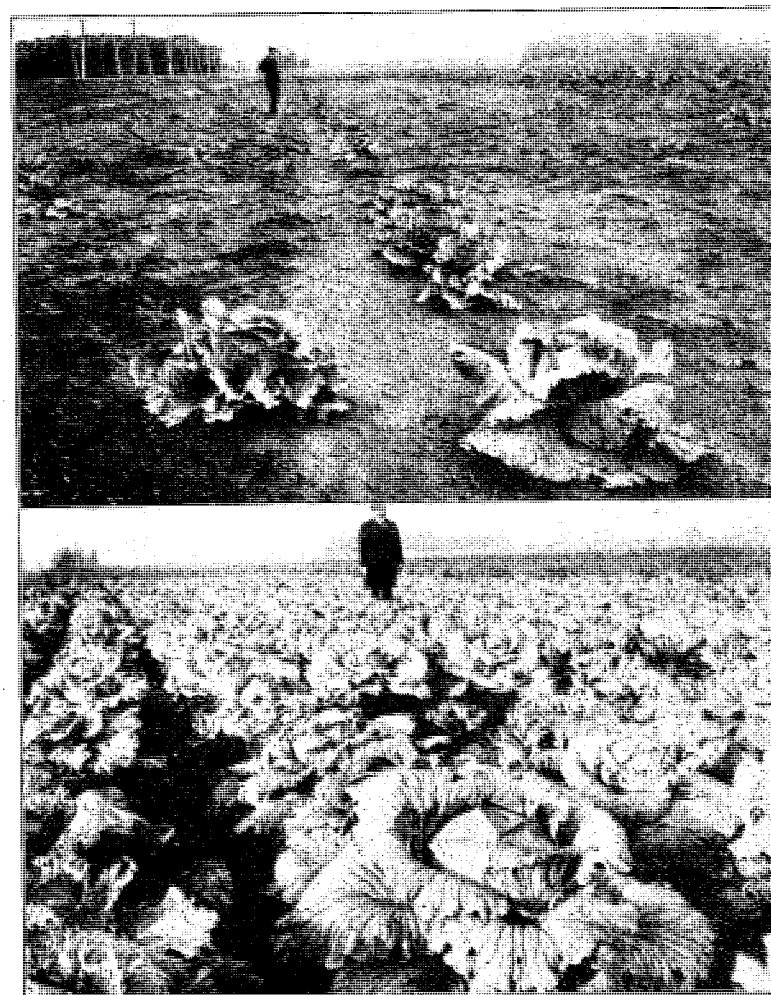


FIGURE 2. USE OF "RESISTANT" CABBAGE SEED SAVES CROP

(A) "Cabbage-sick" field (Racine) in 1911, plants nearly all destroyed.  
(B) Same field in 1912, plants grown from "resistant" seed.

considerable injury in this state for the first time. Our growers should at once adopt the measures for its control which have been worked out in the East. Observations on the fungi which cause diseases in the curing shed have been continued, and

a number of different fungi have been found to be capable of producing shed troubles under certain conditions.

The "black rot" of tobacco, a disease occurring during fermentation, has been conclusively shown to be due to a fungus, *Sterigmatocystis nigra*. The determination of the cause of this trouble has opened up the possibility of several different methods for its prevention, especially the control of the moisture content of the leaf and of the temperature of fermentation.



FIGURE 3. EFFECT OF STEAM STERILIZATION OF TOBACCO SEED BEDS

Plants on sterilized soil show increased growth and freedom from weeds. Right, not sterilized, but weeded; left, sterilized, and not weeded.

#### PLANT DISEASE SURVEY

While the year on the whole has favored crop growth, Professor Jones reports that certain plant diseases have likewise been favored by weather conditions. With potatoes in general there has been this year but little disease. The moist, cool condition of late summer, however, led to a recurrence of the late blight, the most destructive potato disease, which has been held in abeyance the two preceding years by the hot, dry summers. Potato rot also occurred in certain localities. While late blight can be controlled by spraying, it is important where the disease occurs to bear in mind that it is perpetuated in seed tubers from diseased fields, unless precautions are taken in seed selection.

The diseases of cabbage this year have proven quite destructive, black leg, black rot and yellows appearing in a number of sections. The necessary precautionary measures to observe in cabbage culture are seed disinfection, a clean, non-diseased seed

bed, sanitary practices with reference to culture, selection of disease-resistant strains, raising one's own seed, and proper crop rotation as well.

Pea diseases this year have not been as serious as last year, owing to the cool, moist weather, favoring very rapid and satisfactory growth. Much disease, however, was found in the incipient stages.

Orchards, especially apples and pears, suffered last year from winter injury occasioned by the severe climatic conditions of the previous winter. This "winter killing" should not be confused with fire blight, which is a specific, communicable, bacterial disease. Apple rust was destructive with certain varieties.

The barley blights were not as destructive this year as the year before, yet were widely distributed over the state and in certain cases caused as high as 40% loss.

Oat smut, which has heretofore been held in abeyance for a number of years through the widespread introduction of the formalin treatment, is now beginning to assume importance, due to neglect of this precautionary treatment. Some fields were found this year in which over 40% of an otherwise good stand was destroyed by the disease.

It is generally recognized that one of the most important ways of conserving agricultural resources is to give due attention to the various plant diseases and pests and their control. This is true not only for the ordinary orchard and garden but is especially true where field crops are concerned.

#### BARLEY DISEASES

Further investigations on the leaf blight of barley, conducted by Mr. A. G. Johnson of the Plant Pathology department, show that there

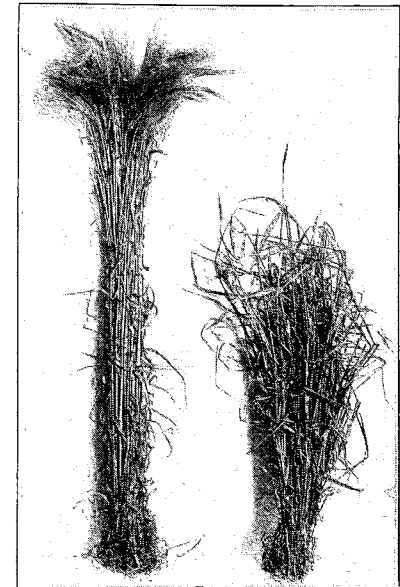


FIGURE 4. BARLEY "LEAF STRIPE"  
One hundred healthy plants on left; same number of diseased plants on right.

are three distinct species of fungi concerned, each of which is capable of producing a specific disease. Apparently the most severe trouble is what has been designated as "leaf stripe" disease, in which the disease manifests itself as light colored stripes in the leaves, which later turn gray and then brown. As the malady progresses, the entire plant collapses. The other two diseases, causing leaf blotch, produce a somewhat similar appearance. All three troubles have been found widely distributed throughout the state and are doubtless as important as stem rust, and may become even more destructive when weather conditions favor. A hopeful aspect of the situation, however, is the possibility of control. Field experiments this summer have shown that the formalin treatment of seed, as is ordinarily practiced for the covered smut of barley and for oat smut, is effective in controlling the leaf stripe, but is less effective against the leaf blotch disease.

#### INSECT PEST SURVEY

Almost perfect crops of fruit were harvested in Wisconsin in 1911 without spraying, due to the nearly complete loss of fruit the previous season caused by the late spring freeze, and the consequent depletion of the insect pests through starvation. But Professor Sanders of the department of Economic Entomology in the last annual report especially emphasized the necessity of close control for the season of 1912, since the great reduction of insect pests had also lessened their natural parasites, and unusually rapid multiplication of the insects would likely occur for several years until the parasites again attained their normal prevalence. This prediction has been only too well verified during the past season.

While the codling moth, the larvae of which are the common "apple worms", was almost wholly eliminated in some regions in 1911, this year the pest was very abundant and caused a large loss of fruit where no control sprays were used, or where sprays were improperly applied. It is estimated that this one pest causes a loss of 15 to 20 millions of dollars each year in the United States, and these losses will continue until fruit growers generally adopt those spray control methods which have been determined by entomologists to be satisfactory, such as spraying with paris green or arsenate of lead.

An unusually severe outbreak of white grubs, the larvae of the June beetle, caused great damage to corn and some other hill crops this year in the southwestern quarter of the state, and in other scattered localities over the entire state more or less injury was apparent. No known remedies for the control of white grubs and wire worms are satisfactory, but preventive measures, consisting of late fall plowing, and discing or harrowing, have proven beneficial in destroying the hibernating forms in the ground. Complete summer fallowing of infested fields will starve the white grubs, through preventing the growth of any plant life. Hogs will also do very thorough work by rooting up the soil and devouring them.

Local outbreaks of several species of cutworms, including the so-called army worm, occurred in the early summer. These can be readily controlled with poison bran mash made as follows: Thoroughly mix one pound of paris green in 30 or 40 pounds of dry bran; moisten slightly with cheap, thin syrup until the mass will hold together well when pressed in the hand. Distribute this poisoned bait about plants to be protected, or sow it broadcast in gardens or fields about sunset, and exclude all poultry until after a rain to avoid danger of poisoning.

The corn ear worm appeared in injurious numbers in some localities. Although this is a member of the cutworm group, the poison bran mash is not effective as a control. Fall plowing and thorough cultivation is our best control in this case.

Strawberry leaf rollers nearly ruined some plantations through lack of the owner's care, when a few sprays of arsenate of lead—4 pounds to 50 gallons of water—would have killed off the larvae. This is our most important strawberry pest in the state, with the possible exception of the white grub.

Leaf mining larvae were unusually abundant on various plants and trees, but judging from the large proportion of these insects infested with parasites, the injuries will probably decrease next year. A new use for nicotine solutions in the control of these larvae was determined, and such good results were obtained experimentally that the method will be tried out further in the field.

Although locusts or grasshoppers were unusually destructive in some sections in 1911, these pests were so greatly reduced in number the past season that serious injury was reported in but few widely separated localities. These changed conditions

were due to the many natural enemies of the grasshoppers, including fungus diseases, internal worm parasites, predaceous mites, and the larvae of the blister beetle.

Professor Sanders especially urges that fall plowing be done wherever and whenever possible in preparing land for planting, because only by following this practice can some of our common field pests be controlled and kept below the danger point.

#### CRANBERRY INSECTS

Mr. Malde has continued the observations on cranberry insects begun several years ago, in cooperation with the U. S. Bureau of Entomology. He reports a scarcity of insect pests this year, which may be attributed to the heavy fall rains that occurred shortly after the cocoons were formed and also this spring when the insects were passing through the changes which take place before the adult stage is reached. The severe winter and scarcity of snow also caused deep freezing.

The tip worm, however, was abundant this year. Damage from the fruit worm, which occasioned much loss in 1911, was slight this year, owing to its comparatively late appearance. In Price county 75 miles from any cultivated bog, and also in Washburn county, on wild marshes, millers of the yellow head vine worm were found late in May feeding on leather leaf and sage bush (*Andromeda*). This indicates that these insects, and also the fruit worm, which was found late in August at work on wild marshes near Phillips and Merrill, are native pests in the state, and only periodically become plentiful enough to be noticed readily.

#### AVIAN TUBERCULOSIS

For several years Professor Hastings of the Agricultural Bacteriology department has been studying the question of tuberculosis of fowls. Reference to the literature on this subject indicates that this disease has not been recognized here in Wisconsin as one of much economic importance, but from the data accumulated by Professor Halpin of the Poultry department, it is evident that it is quite widely spread throughout our state. With the increasing importance which is now being given to the poultry industry, it is decidedly important that

those interested in poultry husbandry should be cognizant of the situation.

Avian tuberculosis, unlike the mammalian form of the disease, is primarily an affection of the liver and spleen. The experiments indicate that the disease is contracted mainly through feeding, that it can be transmitted from fowls to such mammals as swine, and that close contact of healthy and diseased birds will transmit the infection. The main danger, therefore, as with the disease in cattle, is in introducing diseased stock into the flock. Unfortunately, the owner cannot safeguard the condition of his flock by applying the tuberculin test to his purchases, as he can with cattle.



FIGURE 5. TUBERCULOSIS OF FOWLS

"Going light," or wasting away, characterizes tuberculosis in chickens. On left, cross-section of breast from healthy fowl; on right, withered breast of tubercular fowl.

#### IMPROVED GRAINS AND FORAGE CROPS

On the Hill farm at the Station, the Agronomy department had under cultivation this year 90 comparative test plots and 183 centgener breeding plots planted to oats, millet, and wheat. Eleven varieties of pedigree barleys were in the advanced breeding plots; 8 varieties of oats were in the field areas to determine yields and other characteristics.

Pedigree rye yielded this season at the Station, 49 to 54 bushels per acre by weight on land which had been previously in alfalfa. This variety of rye has undergone careful selection by the Agronomy department for a number of years, and has now been disseminated through the state so there are about 1,200 centers where pedigree seed may be obtained.

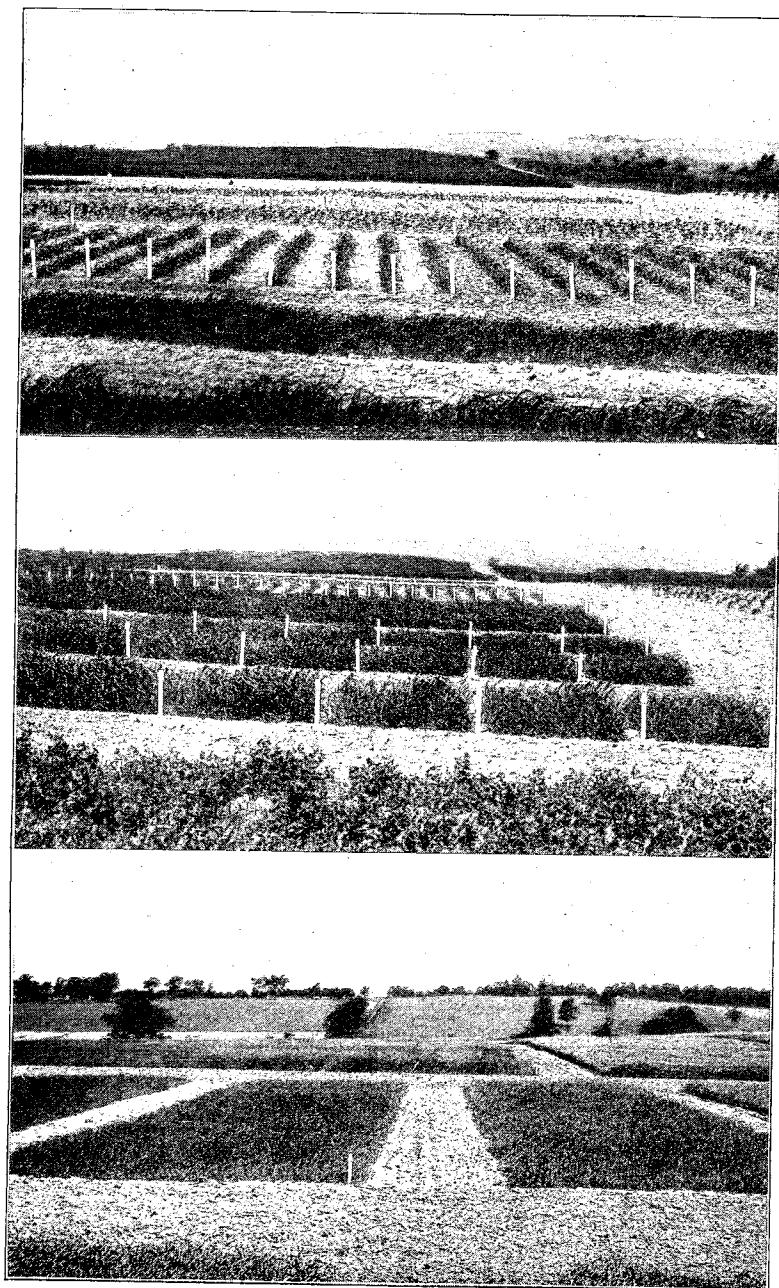


FIGURE 6. GRAIN BREEDING PLOTS AT THE HILL FARM

Starting with the head-to-the-row test plots (a), the next year the best hundred plants are developed in centigener plots (b), after which increase plots (c) are grown.

The pedigree barleys heretofore developed have been under test a number of years. The breeding plots on the Agronomy fields this year yielded from 44 to 57 bushels per acre. These varieties have now been in the hands of the members of the Wisconsin Experiment Association for five years. In over 1000 reports collected during this time, the pedigree varieties showed an average yield of 4.9 bushels more than the best competing varieties. An important feature of these pedigree barleys is the fact that the kernels are of uniform size, vigor, and quality, thus on account of uniformity in germination being far superior to the ordinary mixed strains for malting purposes.

The test plots of oats yielded from 68 to 110 bushels per acre, which is 20 bushels more than ever before grown on our increase plots under ordinary farm conditions. An interesting report was received by Professor Moore from one correspondent who planted one bushel of Wisconsin Pedigree No. 1 oats rather thinly, making it cover nearly an acre. He reported a 90 bushel crop from such seeding. This seems to indicate most excellent stooling properties in this strain.

Considerable work has also been done in crossing barleys, especially the bearded pedigree, with the beardless barley. About one hundred crosses were made on wheats and fifty on oats, from which future selections will be made.

On the county demonstration station at Superior, excellent results were secured this year in growing flax. A good yield was produced on planting made even as late as the first of June. This crop seems well adapted to new breaking, especially since virgin soil is always free from the "wilt", and therefore insures good yields. Where land is cleared in the spring, a cash money crop can be secured the first season. Sixteen to 18 bushels of flax have been secured on the red clay for the past three years. As there are linseed mills for the grinding of flaxseed, and also elevators for the handling of the same at both Superior and Duluth, it is possible to dispose of the product advantageously in this portion of the state. Climatic conditions are apparently very suitable, as flax is a cool weather crop.

Good results have also been secured in breeding and selection work at the branch stations. Professor Delwiche of the Agronomy department who has charge of all the work of that department in upper Wisconsin, reports on the sandy soil at the Spooner station a yield of 73 bushels per acre of Wisconsin



No. 8 corn, which has been especially acclimated for the northern part of the state. This corn matured fully in this section which was once considered far outside the corn belt. At the Ashland branch station, on the heavy red clay, Pedigree No. 8 wheat, a strain of Kharkoff winter wheat, yielded 35 bushels per acre.

#### ALFALFA CULTURE

As alfalfa seems destined to become one of our most important and valuable crops, the Agronomy department is conducting extensive trials on various phases of its culture. These include studies on the quality and hardiness of alfalfa raised in Wisconsin from southern and northern grown seed, from seed produced on irrigated and dry land, and from the much advertised, imported Grimm seed. The results so far secured indicate that the variety sown is not so important as the vitality of the seed.

While the common and usually recommended rate of seeding is 20 pounds per acre, the statement is now being made by some that good stands of alfalfa can be secured in Wisconsin by seeding with as little as 8 pounds. Tests are in progress here at the Station, also in cooperation with 250 members of the Alfalfa Order of the Experiment Association, to determine the best rate of seeding for this climate, as well as the best time for summer and fall seeding.

The experimental work in progress at each of the branch stations includes tests of the value of seeding with and without a nurse crop, liming the soil, inoculation with soil and commercial cultures, and the application of manure. At the Spooner branch station, inoculation with soil gave better results than the use of a commercial culture.

On the Kennan clay loam soil at Conrath, liming was of benefit in securing a good stand of alfalfa. Here, also, inoculation with soil proved superior to either no inoculation or inoculation with a commercial culture.

#### CRANBERRY CULTURE

The Station bog at Cranmoor in charge of Superintendent Malde again demonstrated this year the value of intensive scientific methods over the more extensive methods of culture. Insur-

ance against injury from summer frosts is practically secured by the "sanded" bog method. In June on five consecutive nights, from the sixth to the tenth, all of the surrounding bogs of the old type had to be flooded for protection. Where the bog was not so handled considerable loss occurred. On the station bog no flooding was done from spring till fall but complete immunity from summer frosts obtained.

The application of commercial fertilizers made several years ago to certain of our station plots continues to show excellent results. Phosphate and nitrate plots yielded at the rate of 150 bbls. per acre while the unfertilized plot produced 91 bbls. per acre. Iron sulfate solution has been used this year with success as a weed killer on new plantings and young vines. Two applications were sufficient to hold many of the troublesome weeds in check and retard grass growth.

The crop this year was good throughout the state, although some loss was sustained by frost in June, especially in the Berlin district, and from flooding in September. The station had the largest crop it has had for years. The high rain fall of the season has, however, injured materially the keeping quality of the fruit.

#### NEW APPLES FOR WISCONSIN

For many years apple seedlings have been grown and tested by the Horticultural department in an attempt to secure better varieties for use in the state. As the seedlings have borne fruit, only those of promise have been kept. Prof. J. G. Moore now reports that three seedlings seem to be worthy of testing out in the field. One of these, a seedling of the McMahan, has been highly spoken of by several fruit growers who have seen it on exhibition. A seedling of the Walbridge gives evidence of being a great improvement over the parent, and a Fameuse seedling, of entirely different type from the parent, seems of merit for Wisconsin conditions.

In addition to the testing of seedlings, the newer varieties of apples have been thoroughly tried. Of those under trial, the Hydes King and Garfield seem suited to Wisconsin conditions and are therefore being propagated for future dissemination.

## HEMP AS A WEED ERADICATOR AND MONEY CROP

Two years ago Professor Norgord of the Agronomy department was successful in eradicating quack grass and Canada thistles from a field on the state prison farm at Waupun by the growth of hemp, preceded by fallowing the previous summer. Not only were these weeds eradicated, but a yield of fiber valued at \$118 per acre was secured. As a result of this success, the past two years 200 acres of hemp have been grown by farmers around Waupun and Fox Lake, a large part being placed on thistle and quack infested lands. The 1911 crop



FIGURE 7. SHOCKED HEMP READY TO "BREAK"

A crop yielding \$80 to \$100 per acre, that will kill out Canada thistles and quack grass is worth considering if your land is infested with these noxious weeds.

yielded from 800 to 1200 pounds of fiber per acre, the long fiber being sold this season for seven, and the short fiber, or tow, for five and one-half cents per pound.

In certain instances where an exceedingly tough quack grass sod was not worked the previous season to kill some of the grass, the hemp was crowded out. Lack of fertility had the same effect. To be sure of getting results, the land should be fallowed during the latter half of the previous year, manured well, and, if possible, plowed just before sowing hemp in the spring.

Trials on upland indicate that hemp cannot be profitably grown on any but the best lands. Aside from a lack of fertility, the greatest difficulty lies in the danger of the soil packing, particularly if this is followed by hot weather. To prevent

this trouble the hemp may be (1) placed on corn land which was in sod the previous year; (2) grown on sod land, or (3) manured with plenty of strawy manure and then top dressed, if possible, with manure not containing too much straw, and thoroughly disced into the soil. Experiments conducted on the Horicon marsh indicate that peaty land will produce a large crop of hemp with good fiber.



FIGURE 8. HEMP KILLS CANADA THISTLES

On left, dead Canada thistle plants with rotten underground rootstocks killed by the dense growth of hemp. On right, vigorous, healthy thistles from margin of same field.

## SEX-LIMITED INHERITANCE IN THE DOMESTIC PIGEON

In order to study the principles governing the inheritance of various characteristics, Professor Cole of the Experimental Breeding department is conducting experiments with small animals, such as pigeons, rabbits, rats, and mice. One of the interesting points already brought out is the relation of sex to the inheritance of color in domestic pigeons. Professor Cole had already shown in earlier work with these birds that dun, yellow, and silver are dilute conditions of the so-called intense colors—black, red, and blue, respectively. In the case of cer-

tain crosses made last year in which the male parent was a dilute (yellow or dun) and the female a black, both black and dun offspring were produced. As the young birds matured, it became evident that all the blacks were males and all the duns were females. Further investigation showed that this was a typical case of sex-limited inheritance, in which in stock bred true for a certain character, one sex (the female in pigeons and poultry) never breeds true to type. These discoveries furnish a satisfactory explanation of certain formerly inexplicable results secured in breeding, where birds bred supposedly "pure" for color have not bred true. Examples of sex-limited inheritance have been found in the case of fowls by other investigators in the inheritance of barred feathers, as in the Plymouth Rock fowl, and more recently, in the inheritance of egg production. Should the same rule prove to hold generally for other domestic animals, it will be a matter of much importance to the practical breeder.

#### SOIL MANAGEMENT

A considerable part of the research work of the Soils department on the management of different soil types is necessarily carried on in various portions of the state.

Studies on the sandy types are in progress at the branch station at Spooner, and also at Crivitz, while the department has entire control of an experimental field on the much depleted sands near Sparta.

On these poor sandy soils Professor Whitson finds, when the growing conditions are so adverse as to make it impossible to secure a catch of clover with a nurse crop, that better results are obtained where the clover is seeded alone. Deep seeding and heavy rolling after seeding, also proved beneficial.

The work in progress at Sparta is on extremely sandy soil that had been so exhausted by thirty years of cropping that six acres of timothy produced only one small load of hay. While only meager returns were secured during the first three or four years, the past two years have shown marked improvement. The results now seem to justify the conclusion that these level sandy soils even of such coarse texture and so low in organic content that they have been left largely without agricultural use may be farmed with fair success if careful use is made of

suitable legumes, supplemented by moderate applications of essential mineral fertilizers.

It has been found that when moderate amounts of potash and phosphorus are applied, good crops of serradella, yellow lupine, and cowpeas may be grown on these very poor, slightly acid sandy soils without liming, while with the same treatment, medium red and mammoth clover fail entirely. However, in 1911, by the application of lime, in addition to fertilizers containing phosphorus and potash, a catch of clover was secured which this year yielded 2.58 tons of hay per acre at the first cutting. Corn and potatoes grown on soil where these legumes have been used as fertilizers have yielded encouraging, though small crops.

Experiments at Crivitz in Marinette County on sandy soils similar in texture and mode of origin to the Sparta field, but in a virgin condition, have yielded more encouraging results, and demonstrate the necessity of adopting methods at the beginning for the maintenance of the initial fertility of such soils. In 1911, plots of this sandy acid soil were inoculated and seeded to alfalfa, with and without the application of lime. This year the limed plot gave 43.3 per cent increase in yield over the unlimed plot.

The change from the old temporary substation at Ashland to the new permanent branch station at Ashland Junction has interrupted the soil work on the heavy clays. Professor Whitson has secured data this season from the old Ashland station confirming the need of phosphorus treatment on that type of soil. An increase of 10% in potatoes and nearly 12.5% in clover hay was secured by application of rock phosphate.

#### TILE DRAINAGE

Professor Jones of the Soils department is continually accumulating data on the efficiency of drainage systems. Where the subsoil is of clay he finds that mains with a capacity which will remove one-quarter of an inch of rainfall per twenty-four hours are sufficient. In cases where there were springs to be drained, however, the maximum discharge has been as high as nine-tenths of an inch in twenty-four hours. This emphasizes the fact that in determining the amount and size of tile it is necessary to consider fully the peculiarities of the area, so as to have adequate discharge. Professor Jones

has in progress studies on peat drainage in Portage county where the underlying sand is used as a basis for under-drainage.

#### STATE SOIL SURVEY.

Work has progressed rapidly this past season on the continuance of the State Soil Survey, which has been carried on co-operatively by the Soils department of this College, the State Geological and Natural History Survey, and the Bureau of Soils of the United States Department of Agriculture.

Two types of surveys are in progress in connection with this work: first, a reconnaissance or preliminary survey, in which it is planned to map in a general way the distinct types of soil in as much detail as is practicable in the present condition of the development of these regions; second, the detailed surveys which are being carried out in the older settled regions of the state, as well as in those portions of the north where intensive development is in progress, such as the fruit region of the Bay-field district. These involve a much more complete and detailed examination of soil conditions.

The field data collected under these conditions are designed to give all necessary information relative to the character of the soil. Chemical and physical examinations are made on type soils in the laboratory.

Reconnaissance work in the northern section of the state has included this season an examination of the soils in Douglas, Bayfield, Burnett, Washburn, Sawyer, Ashland, Forest, and Florence counties. Also, in connection with the State Forestry department, examinations of soils have been made in part of the state forest reserves, to determine the agricultural value of certain lands.

The field work of detailed soil surveys was completed in 1911 in Fond du Lac, Juneau, La Crosse, Kewaunee, and Columbia counties, and in 1912 in Jefferson county, while in Bayfield and Dane counties, similar surveys have been started.

In all eighty-five different types of soils, which have been classified into seventeen series, have been described in the detailed work. The area already covered in the survey is shown in Figure 9, the year in which the survey was completed in each county being indicated. Much time must necessarily elapse after the completion of the field work, before the analyses of the soil

samples are completed, and reports are published. As the reports for the various counties are brought out, the fact will be advertised in the local papers. Reports are now available for only the western area mapped by the Geological and Natural History Survey and for the reconnaissance survey of Marinette county.

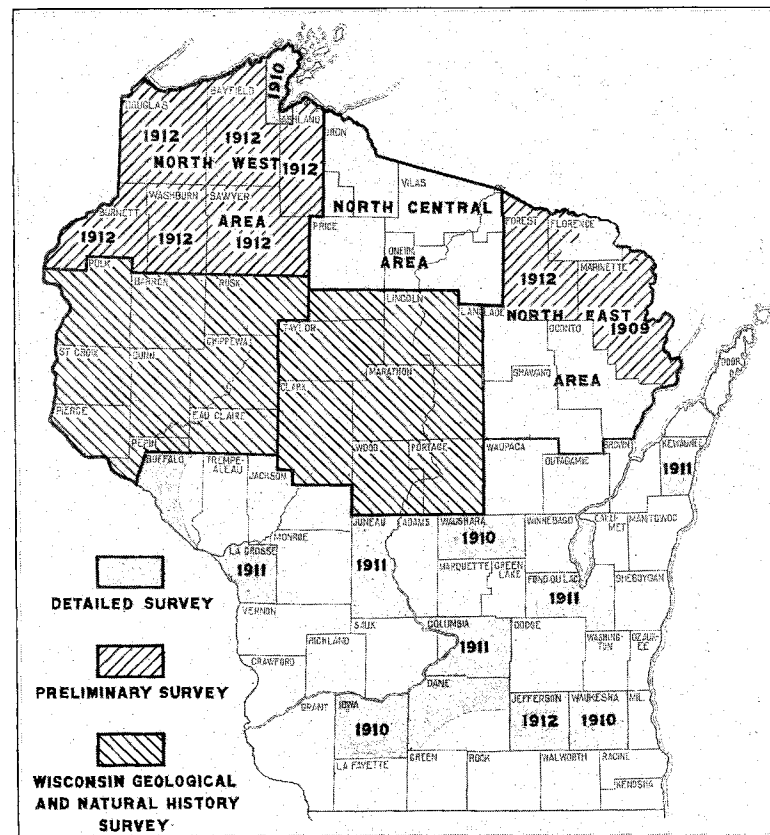


FIGURE 9. PRESENT STATUS OF SOIL SURVEY

A knowledge of what the soils are in any region is a prerequisite to any suggestions as to the best methods of management.

#### CONDITION OF PHOSPHORUS IN SOIL AND AVAILABILITY OF VARIOUS PHOSPHATES

Many Wisconsin soils which are high in total phosphorus, are, however, deficient in available phosphorus as measured by

solubility in dilute acids, and will generally respond to phosphorus fertilizers. Professor Peterson of the Soils department has accordingly been studying the condition of phosphorus in typical soils, especially peat. By oxidation of the soil with varying amounts of hydrogen peroxide and extraction with dilute acid, he finds that as the organic matter is destroyed the amount of soluble phosphorus is increased. There is a corresponding increase in the solubility of iron and aluminum, but the solubility of calcium and manganese is not increased, nor is the solubility of the nitrogen increased in a constant ratio. These results tend to show that the increased solubility of the

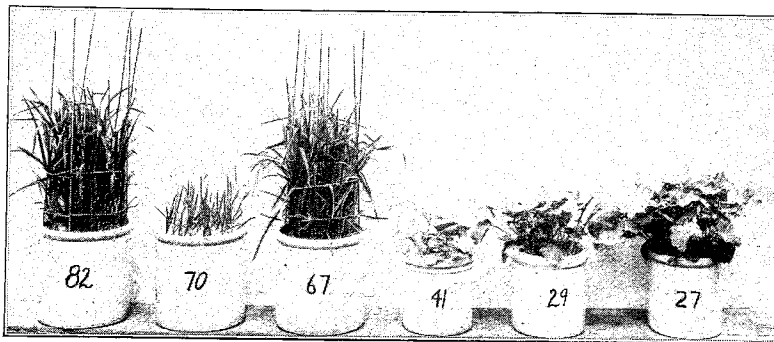


FIGURE 10. AVAILABILITY OF IRON PHOSPHATE TO OATS AND RAPE

Oats made nearly as good growth on ferric (iron) phosphate (82), as on acid phosphate (67), the growth being much better than on rock phosphate (70). With rape the results are strikingly the reverse, rock phosphate (29) producing much better growth than ferric phosphate (41).

phosphorus, though it is caused by the destruction of organic matter, comes, in large part, from iron and aluminum phosphates, which are, before the oxidation of the soil, protected from the action of the acid by being inclosed within particles of organic matter.

Mr. Truog of the Soils department has continued the study of the loss by leaching of phosphorus from heavily manured soils, and on the solvent action of organic matter on rock phosphate. He is also investigating the availability of the different forms of phosphate to various plants. In greenhouse tests oats made much better growth on freshly precipitated and dried ferric phosphate than on rock phosphate, while with rape the results were strikingly the reverse, as is shown in Figure 10.

#### RELATION OF BACTERIA TO THE AVAILABILITY OF PHOSPHATES

During the past year Professor Totttingham of the Agricultural Chemistry, and Professor Hoffmann of the Agricultural Bacteriology department have continued their studies on the action of fermenting manures on phosphates added as reinforcing materials. They have found that fermentation over periods of from three to six months caused a marked decrease in the amount of water-soluble phosphorus in manure alone, or in mixtures of manure either with rock phosphate (floats), or with acid phosphate. In the case of the manure-floats mixture, less than half as much water-soluble phosphorus was found after fermentation as was originally present.

The addition of either chloroform or formaldehyde, which practically inhibited bacterial action, greatly reduced the decrease in water-soluble phosphorus in such mixtures of manure and floats, indicating that the loss occurring during fermentation was due to bacterial development. This view was supported by the fact that the growth of manure organisms upon media supplied with phosphorus in the form of the water extract from a fresh manure-rock-phosphate mixture caused a decrease of over 40% in the amount of water-soluble phosphorus, a loss comparable to that which occurred in the fermenting mixtures of manure. It was further found that about half the phosphorus in fresh, intact bacterial cells was apparently in the form of insoluble compounds (nucleins).

In conformity with the laboratory results, in greenhouse trials with barley, a 37% greater yield of grain was secured by the simultaneous application of fermented manure and soluble phosphate, than by the use of a mixture of manure and soluble phosphate which had previously undergone fermentation. On the other hand, in a second crop grown upon the same soil without any further fertilization, the fermented mixture proved superior, this reversal of results indicating that the phosphorus rendered insoluble by bacterial action was now available to the crop.

In similar trials in which a fermented mixture of manure and insoluble phosphate was compared with freshly mixed manure and phosphate, no difference in yield was obtained in the first crop, but in the second crop the fermented mixture produced the greater yield. This seems to indicate that the phosphorus

changed by fermentation, though less soluble in various chemical solvents, was more available to the second crop.

#### EFFECT OF LEVEL OF SULFUR SUPPLY ON PLANT GROWTH

As has been previously reported, Professor Hart and Mr. Peterson of the Agricultural Chemistry department found by improved methods of analysis that the sulfur content of cereals is nearly as high as their content of phosphorus, while other plants may contain much more sulfur than phosphorus. Their work also indicated that three times as much sulfur may be lost in drainage waters as is brought to the soil in rain. Analyses of cropped soils and adjacent virgin soils showed that the cropped soils contained about 40% less sulfur. These data therefore raise the question as to whether the natural soil supply of sulfur is adequate for permanent crop production.

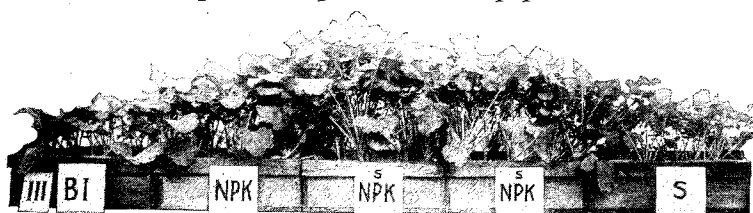


FIGURE 11. SULFUR FERTILIZATION INCREASES GROWTH OF RAPE

Sulfur, as well as nitrogen, phosphorus, and potassium, may be a limiting factor in the growth of certain crops. Boxes from left to right: no fertilizer; "complete" fertilizer (N, P, K.); third and fourth boxes, complete fertilizer, plus sulphate; fifth box, sulphate alone.

To determine the effect of sulfur fertilization various plants have been grown by Professor Tottingham of the Agricultural Chemistry department under greenhouse conditions with and without the addition to the soil of sulfur fertilizers. In the case of rape and radishes, both plants high in sulfur, sulfur fertilization has had a marked effect on the yield of dry matter. With rape grown under greenhouse conditions on soil from the Hill farm, supplying a sulfur fertilizer (gypsum, or land plaster) in addition to nitrogen, potassium, and phosphorus gave an increase of over 30% in the dry matter of the crop, as is shown in Fig. 11.

#### INFLUENCE OF GREEN MANURING UPON GERMINATION OF SEEDS

Last year a southern student at the College reported the failure of some ten acres of cotton to germinate, where it had been

sown immediately after plowing under green clover. On the other hand, on a similar field planted with the same seed, but which had not been green manured, normal germination occurred. Professor Hoffmann has accordingly begun a study of the effect of green manuring upon the germination of seeds subsequently sown. In pot tests in the greenhouse he has incorporated with the soil an amount of green clover corresponding to that applied under field conditions, and has then sown various seeds, in all cases sterilizing one series of pots, while another was allowed to remain in a normal condition.

It has been found that the decomposition of the clover somehow affects cotton seeds, but does not have any material effect



FIGURE 12. GREEN MANURING PREVENTS GERMINATION OF COTTON

When 1.5% of green clover was mixed with the soil (Jar 2) or 3.0% (Jar 4), and the whole sterilized, germination was as good as where no green manure was added (Jar 1). However, when 1.5% (Jar 3) or 3.0% (Jar 5) of green clover was added, and normal decomposition allowed to go on, germination was prevented.

on the germination of corn, wheat, and clover. Two experiments conducted with flax have, however, shown a similar detrimental effect to that produced on cotton. The results so far secured indicate that the decomposition of green manures results in a reduction of the oxygen supply and an increase in the carbon dioxide present in the soil atmosphere. It is thought that this change in gaseous content of the soil prevents the germination of the cotton and flax seed, which contain a high percentage of oil, and so require more oxygen for germination than such seeds as corn, clover, and wheat.

#### INCREASE IN NITROGEN FIXATION OF SOIL DUE TO APPLICATION OF CARBOHYDRATES

Professor Hoffmann has also studied the effect of various soil treatments on the bacterial activity of the soil at the Hill farm.

In the studies on this soil he finds that the application of sugar markedly increases the fixation of atmospheric nitrogen by the soil organisms which are able to fix nitrogen in the absence of any legume. This increased activity of these bacteria produced an actual increase of nearly 1,000 pounds of nitrogen per acre foot in three years. Similar results, though not quite so striking, were secured by the application of starch to the soil. It is interesting to note that when kainit and floats were applied together with either sugar or starch, the increase in the nitrogen fixing power was not so marked.

#### BACTERIAL AND CHEMICAL FACTORS IN THE RIPENING OF CHEDDAR CHEESE

The studies in cooperation with the Dairy Division on the bacterial and chemical factors concerned in the manufacture and ripening of cheddar cheese have been continued by the departments of Agricultural Bacteriology and Agricultural Chemistry.

As previous investigators had found the group of lactic acid bacteria the only one of constant occurrence in cheddar cheese, it has been quite generally believed that no other single group or at least single species of bacteria was absolutely essential to the ripening process. Professor Hastings and Miss Evans have found, however, that following the period of activity of the lactic bacteria, the group of high-acid-forming bacilli, or rod-shaped organisms, always make their appearance and gradually increase in numbers until they form 50 to 99 per cent of the total bacterial content. In 11 out of 13 cheese examined the coccus or round forms of bacteria have also been found to predominate at some time, varying from the 14th to the 161st day, making it probable that these forms are constantly present in large numbers in cheddar cheese.

Over 250 bacterial cultures, isolated from normal cheddar cheese, have been studied in detail and arranged in groups according to their power to ferment various carbohydrates. The results so far secured tend to show that the high-acid bacilli which ferment the more resistant test substances give a rank flavor to the cheese if they develop in very great numbers, but on the other hand, it requires lactic bacteria or cocci which do ferment some of these more resistant substances for the development of the best cheddar flavor.

In making cheddar cheese, as a guide in the amount of starter to be added to the milk and also in subsequent operations, it is important to know as accurately as possible the rate at which acid will be developed during the process. Of course, this depends upon the number of lactic bacteria present in the milk. During the so-called "period of incubation" of the milk, while the bacterial content may be increased many thousand fold, the acidity remains stationary, so far as can be determined by titration methods. In these studies a considerable number of tests has shown that small differences in acidity are much more easily detected by the rennet test than by titration, and hence, the rennet test is a much more delicate means for the cheese maker to use in determining the condition of his milk.

It seemed very questionable from preliminary work whether the production of flavor in cheddar cheese was alone due to the decomposition of the casein, as such decomposition might be quite complete and yet no typical flavor appear. The chemical studies on the factors involved in the ripening process, carried on during the past six years under the direction of Professor Hart, have therefore been confined to studies of the non-nitrogenous constituents occurring in cheese. In the earlier work, reported in Research Bulletin 11, it was demonstrated for the first time that certain volatile compounds (esters) were progressively formed during the ripening process. Volatile fatty acids and alcohols were also found in varying amounts in normal cheese. These non-nitrogenous compounds, which were important in producing a characteristic cheese aroma, were not formed in chloroformed cheese or milk.

During the past two years, Mr. Flint, the chemist detailed by the Dairy Division, has studied the occurrence of these non-nitrogenous constituents in good and poor cheese, in an effort to determine the cause of the difference in flavor. No very definite relation was found to exist between the various kinds of these volatile compounds and the flavor of the cheese. Nevertheless, since there are differences in these constituents of the cheese which can have been produced only by bacterial activity, a study is being made of the by-products produced by pure cultures of the various groups of organisms normally present in cheese. It is hoped that it may be demonstrated that certain bacterial types are responsible for the production of definite compounds which cause flavor.

It has been found that representatives of the coccus group which are abundant in cheese at some time during the ripening process, produce large amounts of volatile acids. Most of these organisms also produced alcohol, but only two were found capable of forming esters. The origin of ammonia in normally ripening cheese has never been hitherto satisfactorily explained, but in these studies it has been found that representatives of both the coccus and the high-acid-producing groups are able to produce this substance.

In this work considerable time has of necessity been devoted to perfecting methods of determining the various compounds. Improvements have been made in the methods of separating and determining active and inactive lactic acid, and also in the Duclaux method for the estimation of volatile fatty acids.

#### CHEDDAR CHEESE FROM PASTEURIZED MILK

The presence of inferior cheddar cheese on the market, and the lack of uniformity which characterizes the product of the present average cheese factory, is due primarily to the variable quality of the milk supply from different farms. In an attempt to produce cheese of uniform quality from milk of variable acidity, which is often contaminated with undesirable bacteria, cheesemakers use methods which vary from day to day, carefully watching each vat at every stage of its manufacture and modifying the process to meet the conditions. Even then the quality and also the yield of cheese varies from day to day.

In an endeavor to devise a process for treating milk daily at the factory to bring it into practically a uniform condition for cheesemaking purposes, Professor Sammis of the Dairy department has developed a process whereby the milk is pasteurized, and then brought to uniform acidity by the addition of a small amount of hydrochloric acid, after which a pure culture starter is added to carry forward the cheddar process. This work has been carried on in cooperation with the Dairy Division of the United States Department of Agriculture.

This process has been carefully compared with the regular factory process for three years at the University creamery, the cheese being cured under different conditions and marketed in many sections of the country.

A greater yield of cheese has always been obtained from pasteurized milk than from raw milk, the average gain in yield of green cheese being 5.37% in 1911. The pasteurized milk cheese varied much less in quality, and averaged better by 3.7 points of total score than the raw milk cheese made from the same milk supply. The cheese sold readily for the ruling market prices, and often above. Even after storage under adverse conditions for one month at New Orleans at a temperature of 75° to 80°F, the pasteurized milk cheese averaged three to eight points better in total score than the raw milk cheese. Pasteurized milk cheese can be cured without injury at 70°F.

Before recommending this new process for general use, it will be given a thorough trial in cheese factories in various localities to test its applicability to different milk supplies. During the past season, the method has been tested in the Prairie factory at Spring Green, one portion of each day's milk being made into cheese by Mr. Bruhn, the cheesemaker detailed by the U. S. Dairy Division. The same gain in yield of pasteurized cheese has been obtained as at Madison, the gain being especially high on days when the raw milk curds were gassy. In so far as uniformity of flavor was concerned, the pasteurized milk cheese was superior to the raw milk cheese, but on many days the pasteurized cheese made at Spring Green contained a great many small holes, usually called "Swiss holes" or "fish eyes," a defect which had never been encountered with the milk supply received at Madison. Efforts are now being made to remedy this defect.

#### DAIRY MANUFACTURING TESTS AND APPLIANCES

During the past year Professor Benkendorf of the Dairy department has perfected a simple piece of apparatus which can be used successfully for measuring the overrun or "swell" in ice cream making, and has also designed and perfected a new way of using a burette for calibrating milk and cream test bottles.

#### MOTTLES IN BUTTER

Professors Sammis and Lee of the Dairy department have continued their work, begun a little over a year ago, on the cause of mottles in butter. By emulsifying dry butter fat, previous-



ly freed from casein by filtering through paper, with water by means of the homogenizer, and then salting the product, butter was produced which showed typical mottles when the salt was not evenly distributed throughout the mass. Mottling of butter may thus be produced entirely independent of the casein. A characteristic sample of this mottled casein-free butter is shown in Figure 13. Examination of such butter under the



FIGURE 13. MOTTLED, CASEIN-FREE BUTTER

This marbled condition seriously depreciates the value of butter. Thorough working is important in preventing this fault.

microscope shows that in the portions which are lighter in color, the water is present in the form of innumerable minute droplets, thus rendering these layers opaque, while in the darker portions, the droplets of water are much larger but fewer in number, thus rendering the butter more translucent.

The results secured in these experiments throw a new light on the whole subject of "mottles" in butter and emphasize the importance of thorough working of the butter to prevent the production of this mottled appearance which seriously depreciates the value of the product.

### ICE CREAM MANUFACTURE

Hitherto little scientific study has been given to the manufacture of ice cream, the various methods and practices resting merely on an empirical basis. Mr. Baer of the Dairy department has begun a study of the value of different modes of procedure, conducting experiments with both the stationary and continuous type of freezers under conditions similar to those employed by commercial manufacturers. Only by such careful studies can this rapidly growing industry be placed upon a scientific foundation.

### PURIFICATION OF CREAMERY SEWAGE

The effluent from septic tanks used for the decomposition of creamery sewage when run onto filter beds usually has a very strong odor, which makes the use of such filter beds objectionable in an inhabited neighborhood. During the past two years Professor Farrington has successfully used a one per cent solution of common bleaching powder for deodorizing both the effluent from the septic tank at the University creamery, and the raw sewage in the drain at the Verona creamery station. The decomposition of the sewage is not checked by the use of this solution, but the offensive odor is greatly diminished.

The deodorizing solution is made by mixing one pound of bleaching powder with 100 pounds of water and allowing to settle. The clear liquid is then drawn off and sprinkled over the filter beds in about the proportion of one gallon to 150 cubic feet, or 1100 gallons, of sewage.

### EFFECT OF RATIONS FROM SINGLE PLANT SOURCES

To determine what would be the specific physiological action of rations restricted to single plant sources, upon cows subjected to the strain of reproduction, an experiment was undertaken five years ago by the departments of Agricultural Chemistry and Animal Husbandry. Young heifers were fed chemically balanced rations from the corn, the oat, and the wheat plant. As the animals reached physiological maturity and underwent the strain of reproduction, it became evident that the ration from the wheat was strikingly deficient, the wheat-fed mothers producing either dead or weak, undersized offspring. The results

of the earlier work on this problem have been reported in Research Bulletin 17 and in preceding Director's Reports.

During the past year attention has been concentrated on attempts to determine the cause of the disastrous effects of the wheat ration. In addition to the ration prepared exclusively from the wheat plant, rations were fed consisting either of wheat grain or of wheat straw, together with parts of other plants. For example, offspring have now been produced by cows on the following rations: (1) Wheat grain and corn

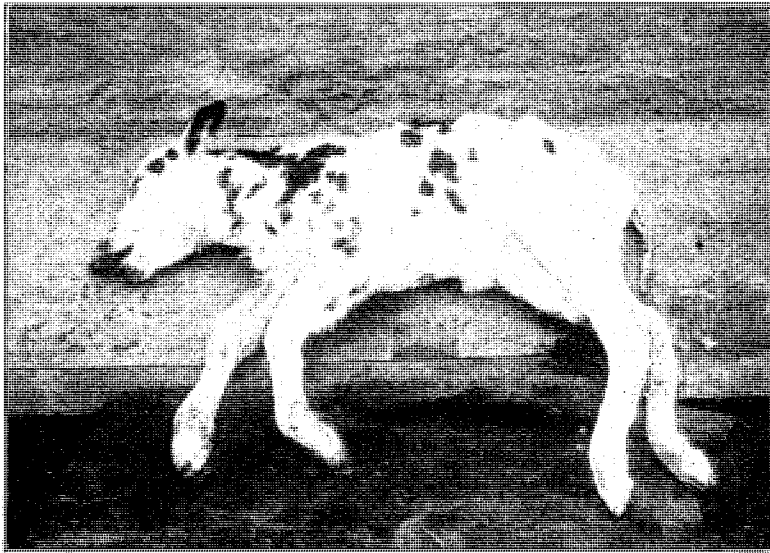


FIGURE 14. CALF OF COW FED WHEAT STRAW AND CORN GRAIN

Calf dead at birth.

stover; (2) corn grain and wheat straw; (3) corn grain with equal parts of wheat straw and alfalfa hay. Upon rations consisting of the wheat grain and corn stover, normal, healthy calves were produced. As soon as wheat straw formed the sole roughage, no matter what grain was used, invariably the urines became acid and weak undersized offspring resulted. However, upon the ration consisting of the corn grain with equal parts of wheat straw and alfalfa hay, normal calves were produced.

These results tend to indicate that the deficiency of the wheat plant is not due to toxicity of any part of the plant, or to an insufficiency of the proteins, but rather to the acid condition

imposed on the animal, caused by an insufficient supply of lime and other alkaline substances in the roughage. While this disastrous effect of the wheat straw was overcome by the addition of alfalfa hay, especially high in such alkaline substances, previous work indicates that it cannot be remedied by the addition of alkaline carbonates. Work is being continued along various lines to throw further light on these problems of great physiological importance.

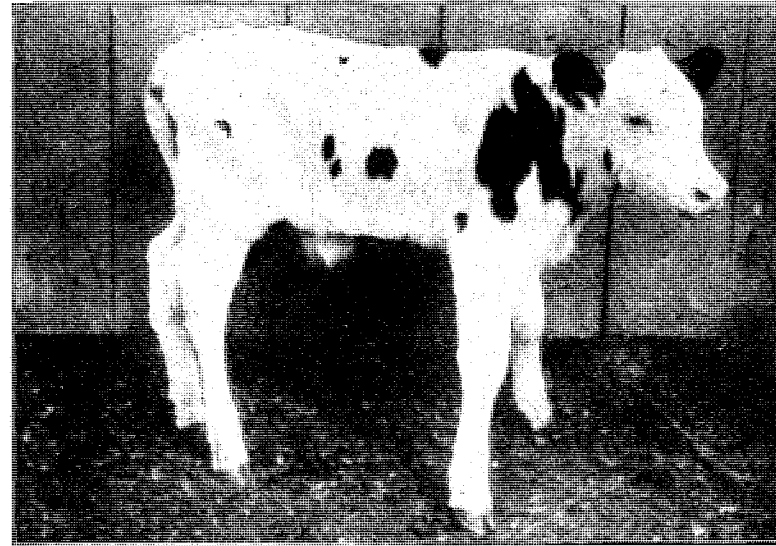


FIGURE 15. CALF OF COW FED CORN STOVER AND WHEAT GRAIN

A vigorous, thrifty calf, normal in every way.

The same line of work was inaugurated with chickens last year by the Agricultural Chemistry and Poultry Husbandry departments. As no roughage could be employed in this case the rations were limited to (1) wheat grain and its products; (2) corn grain and its products; (3) oat grain and its products; and (4) barley and its products. The pullets which were limited to the wheat grain and its products made as rapid growth and reproduced chicks with apparently as great vitality as pullets fed rations from any of the other grains. There were differences in the number of eggs produced on the various rations, but individuality, as well as feed, may have been a factor in producing this result.

## MINERAL REQUIREMENTS OF ANIMALS

The Agricultural Chemistry and Animal Husbandry departments during the past year have continued their studies on the mineral requirements of farm animals, special attention having been given to questions concerning lime (or calcium) and phosphorus. The claim has often been made that feeding to pregnant animals a ration high in mineral matter, especially lime, will cause undue development of the skeleton of the fetus, with subsequent difficulty at birth. This problem has been thoroughly studied with swine by feeding brood sows rations high in lime. The results show that no such thing occurs, but that the size and lime content of the fetus skeleton is kept very constant when widely different amounts of lime are consumed in the food.

Further data on the lime requirements of farm animals have been collected on growing and mature swine, and on a mature goat, both dry and in milk, as it was apparent that the amount of lime demanded would turn on whether the animal was growing, producing milk, or merely maintaining itself. An interesting observation in this work was that the bulkiness of the ration determined to a considerable extent the amount of lime lost in the feces. In other words, a hard pressed animal machine, as a milch cow or goat, with a very large consumption of food and a correspondingly large fecal residue, will lose a large amount of lime from the body in the feces. This emphasizes the desirability of liberal supplies of lime in the rations for such animals.

It was formerly believed that animals could only build the important phosphorus containing organic compounds in the body tissues from similar organic compounds furnished in the food. Thus fish was considered a superior brain food, since it was high in organic phosphorus compounds. Professor McCollum has studied this problem with the hen, which in the egg produces large amounts of lecithins (phosphorus containing fats.) Eggs containing normal amounts of lecithins were produced on rations which contained no such compounds. This experiment, together with Professor McCollum's previous work in which he showed that rats could make appreciable growth on rations containing only inorganic phosphorus, show that the animal has much greater power of building the organic compounds found in its body than has generally been believed.

In studying certain fundamental problems in animal nutrition, Professor McCollum is conducting numerous experiments with growing rats, supplied with distilled water and fed various organic nutrients together with inorganic salt mixtures. He has not been able to produce normal growth with young rats on any natural grain, but has secured normal growth on skim milk powder, and on egg yolk. Although rats did not grow when fed the wheat kernel alone, or the wheat kernel plus wheat gluten, when mineral salts were added so as to make the total content of the mineral matter in the diet closely similar to that of milk powder, normal growth was produced for 70 days. Rats grew normally for 75 to 100 days on a ration consisting of pure casein and dextrine, if salt mixtures were supplied, which made the mineral content of the ration similar to that of either milk or egg yolk. However, when the same casein and dextrine mixture was fed with a salt mixture which gave the ration a content of mineral matter closely similar to that of the wheat grain, growth was suspended completely.

On either the last ration or on the ration consisting of wheat and wheat gluten, both of which contain a large amount of magnesium compared with the amount of calcium present, growth was induced in some degree both by the addition of calcium, or by the subtraction of magnesium.

These experiments show that not only must sufficient amounts of the necessary mineral elements be supplied, but also that there must be a proper balance between them, a fact hitherto not sufficiently recognized. Since the mineral content of egg yolk is highly acid and that of milk slightly alkaline, yet both lead to normal growth, it is evident that for this species an acid diet is not injurious. This may not be true for herbivora.

## INFLUENCE OF SULFUR IN FEEDS UPON WOOL PRODUCTION

As practically all proteins contain considerable sulfur, in all probability farm animals in general obtain sufficient sulfur in their usual rations. The sheep, however, produces in its wool a product unusually rich in sulfur. This fact, together with the practice of good shepherds of supplying their flocks feeds especially rich in sulfur, suggested that a large intake of sulfur might be conducive to the production of an increased yield of wool or wool of better quality.

Accordingly during the past three years experiments have been carried on by the departments of Agricultural Chemistry and Animal Husbandry in which four lots of four sheep each of the wool type have been fed a ration as low in sulfur as could be made from the ordinary farm grains and hay; the same ration, plus sugar beets, a succulent feed low in sulfur; also the same ration, with rutabagas, a succulent feed high in sulfur; and the same basal ration with calcium sulfate, as a source of inorganic sulfur.

It has been found that neither the average gross weight of the fleeces, nor the proportion of pure wool fiber to the total weight was greater on the high-sulfur than on the low-sulfur rations. The percentage of sulfur in the pure fiber of the various lots was practically the same, as was the yolk in the fleeces.

It is evident from the results of these experiments that the normal dry rations of grain and hay contain ample sulfur for wool production, and that additional supplies seem to have no influence upon the proportion of pure fiber formed.

#### INFLUENCE ON GROWTH OF SWINE OF AMOUNT OF PROTEIN FED

Numerous practical feeding trials have led animal husbandry workers to hold that growing animals need, for the most economical production, a relatively narrow ration, i. e., one high in protein. During the past year Professor McCollum of the Agricultural Chemistry department has conducted metabolism experiments with pigs to determine the influence of the amount of protein in the ration, other factors remaining constant, on the tendency of young pigs to retain nitrogen for growth. All the animals received rations supplying the same amount of energy per pound of body weight, but the protein supply was fixed at 5, 10, 15, or 20 times the amount required for maintenance. When five times as much protein was fed as was required for maintenance, making a ration having a nutritive ratio of 1:11, only 10% of the nitrogen fed was retained. When twice as much protein was supplied in the food, 10 times the maintenance requirements being fed, or a ration with a nutritive ratio of 1:5.5, 23% of the nitrogen in the food was stored up in the tissues. When the amount of protein fed was increased to 15 to 20 times the amount required for maintenance, the same percentage was still stored. In other words, when the very narrow nutritive ratio of 1:2.7

was fed, supplying 20 times the protein required for maintenance, over twice as large a percentage of the protein fed was stored for growth as on the wide ration which supplied only 5 times the maintenance requirements.

#### VALUE FOR GROWTH OF NITROGEN IN ALFALFA HAY

For many years a problem of great dispute among scientists has been the question of whether animals can use for growth the so-called amid nitrogen, which is present to a considerable amount in such feeds as roots, silage, and hay, in the same manner as they use the nitrogen in the form of the more complex true proteins. As one-fourth of the total nitrogen of alfalfa hay is in the form of this amid nitrogen, it is a matter of considerable importance in the use of this feed as a source of protein, to learn whether all of the nitrogen is of full value, or whether the amid nitrogen must be considered worthless for growth and other vital purposes.

To throw more light on this question, experiments have been carried on during the past two years by the departments of Agricultural Chemistry and Animal Husbandry. In these trials young, growing heifers were fed rations in which alfalfa hay was the sole source of nitrogen, while others were fed rations from the corn plant, in which practically all of the nitrogen was in the form of crude protein. Long continued experiments have now been conducted with four different animals in which accurate records have been kept of the intake and outgo of nitrogen. Since these growing heifers uniformly stored as high a percentage of the total nitrogen of alfalfa hay as they did of the corn plant, we must conclude that the amid nitrogen was not worthless for growth, but that with these animals the entire nitrogen of alfalfa hay was of full value.

#### LESSONS FROM THE WISCONSIN DAIRY COW COMPETITION

As a part of the general campaign for the advancement of Wisconsin dairying, the Wisconsin Dairy Cow Competition was conducted by Professor Woll for a two-year period ending November, 1911. Of the 506 entries made in this competition, complete yearly records of production and feed consumption were obtained from 395 animals. The immediate value of the contest to the breeders who competed, and to the live stock in-

terests of the state in general, has already been very great, both through the publicity received and the stimulus to individual breeders and the farmers in their respective localities. This value, important though it is, is insignificant compared with the influence which would be exerted if all Wisconsin farmers carefully studied the results and lessons secured in this work.\*

A most important fact brought out by the extensive data is that the large cows within each breed were, as a general rule, more economical producers than the small ones. Though the large animals were heavier eaters, their production was enough

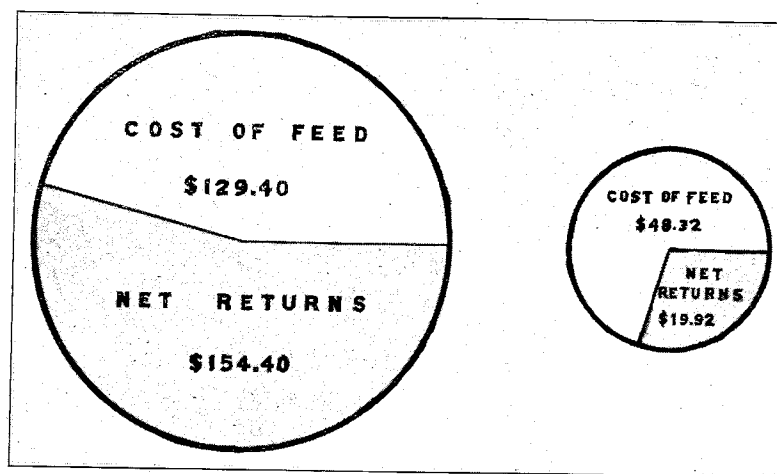


FIGURE 16. NET RETURNS FROM BEST AND POOREST COWS

The best cow consumed about two and three-fourths times as much feed as the poorest cow, but on account of her much greater production, her actual net returns were nearly eight times as great.

greater to make their net returns larger than in the case of the small animals.

The cow that ranked first in actual production of butter fat, when compared with the lowest producer in the Competition, consumed feed costing 168% more, but in return produced 882 pounds of butter fat, or over four times as much as the poorest one. In actual net returns the best animal was nearly eight times as profitable as the poorest cow. Who is there that would consciously feed, milk, house, and care for eight animals, in-

\*The general results are published in Bulletin 226 while the detailed data and the more critical study are given in Research Bulletin 26 of this Station.

stead of one, if he knew just what was taking place in his herd? This example is by no means extreme, since perhaps not more than one-third of the cows on Wisconsin farms yield better results than were actually obtained from this lowest producer in the competition, which gave nearly 4400 pounds of milk, and 218 pounds of fat.

A study of the rations consumed shows that the large producers ate from 18 to 26 per cent more total feed, and from 38 to 61 per cent more concentrates than the low producers. The feed of the former class was thus made up of a larger proportion of concentrates and of smaller proportions of pasture grass and hay, or other dry roughage, than that of the low producers. The results obtained in the competition illustrate in a striking manner the fact that a large dairy production cannot be secured except by furnishing a large supply of feed. The increase of 23% in the total amount of feed eaten by the 25 best cows in the competition, compared with the 25 poorest cows, was accompanied by an average production 78% greater than the poorer cows.

#### CORN SILAGE FOR BEEF CATTLE

Mr. Tormey of the Animal Husbandry department has conducted feeding trials for the past three years to determine the value of corn silage for fattening steers, with results which agree in showing that it is a most economical feed for this purpose. In the trial of last winter three lots of five 2-year-old steers each, were fed the same concentrate allowance (averaging 12.55 pounds of corn meal, 2.05 pounds bran, and .25 pound cotton seed meal), with roughage allowance as follows: Lot I, corn silage 32.83; Lot II, corn silage 7.32, alfalfa hay 8.83 pounds; Lot III, alfalfa hay 11.72 pounds. It should be stated that the steers were used for class room work, and hence subjected to more exercise and worry than usual, which doubtless had some effect upon the cost of putting on the gains.

During the feeding period of 104 days the steers fed silage as the sole roughage made the most economical and the largest gains, the average daily gain per steer being 2.73 pounds. In rapidity and economy of gains, Lot II, fed silage and hay as roughage, were second, producing nearly as large gains as the silage fed lot. In this short feeding period the steers finished

fully as well on corn silage alone as on alfalfa. After the steers got on feed no digestive troubles were experienced through the use of silage. Toward the end of the feeding period, however, the silage fed cattle had to be watched more closely than the steers fed either hay or hay and silage, and the allowance of corn silage cut down, owing to a tendency to get off feed. On the other hand, the steers in the silage-alfalfa lot were always greedy for their feed and consumed a large amount of roughage. The results show that it is profitable to feed silage as the sole roughage to fattening steers under the present average market conditions. This is especially true when the price of hay is high.

SILAGE FROM SUGAR BEET TOPS AND SHOCKED CORN

As about 250,000 tons of sugar beets are now raised annually in Wisconsin, the best utilization of the beet tops is of considerable importance. Last fall Professor Humphrey of the Animal Husbandry department ensiled this material with shocked corn. Though the silage had a slightly stronger odor than ordinary corn silage, it was not offensive. The cows seem to relish it, and did as well as on the regular corn silage. Chemical analysis showed that this silage had practically the same composition as clear corn silage.

After the beets were removed from the field, the tops, which had been left in small piles, were run through an ensilage cutter with an equal amount of corn fodder taken from the shock. By throwing the beet tops onto a layer of corn and cutting them both together, no difficulty was experienced. Enough water was added to the cut material to give it the proper moisture content, and make it pack well when two men tramped it during the time of filling. The production of carbon dioxide gas from the respiration of the fresh beet leaves is sufficient when the cut material is tightly packed to keep the whole from developing mold and other undesirable fermentations.

COST OF PRODUCING BUTTER FAT

The cost accounting work conducted by the Department of Agricultural Economics under the direction of Professor Taylor, in cooperation with the Office of Farm Management of the United States Department of Agriculture, represented by Mr. Juve, has been continued the past year to obtain further figures

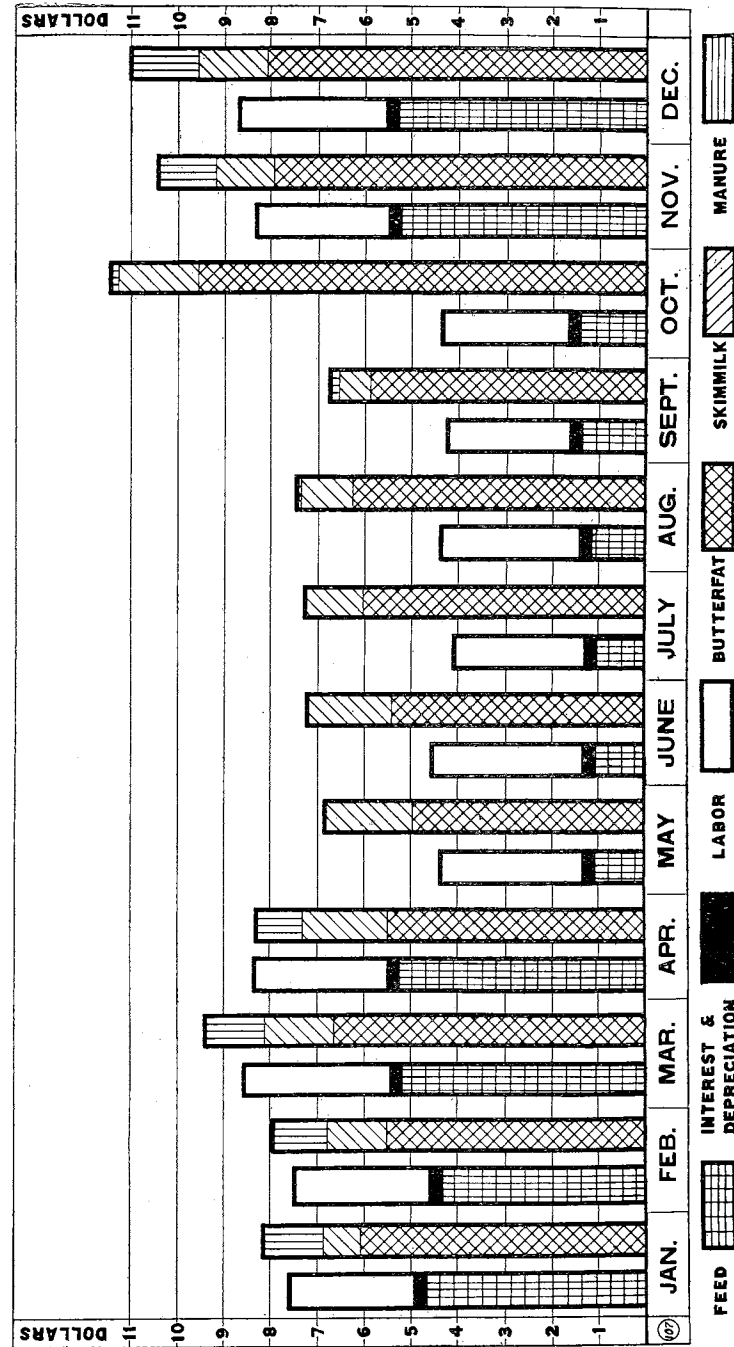


FIGURE 17. COST ACCOUNTING STUDY ON WISCONSIN DAIRY FARM  
In this particular herd, the price of butter fat in winter was not great enough to offset the increased cost of feed.